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Analysis and Investigation of the Cause of Increased Energy Consumption in a Centrifugal Dewatering Plant

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Abstract: Today, it is estimated that up to 20-25% of the world's electricity consumption is for pumping equipment. Up to 85% of the operating costs of pumps are electricity costs. The E.F. of pumping systems often does not exceed 10-20%, while the E.F. of pumps is 50-90% [1,2].

Since reducing energy consumption is a priority for the company, economic efficiency in general is directly linked to the use of pumping equipment.

In this paper we discuss the current problems in analysing and investigating the pressure characteristics of centrifugal pumps.

Keywords: centrifugal pumps, economy of operation, energy efficiency improvement, optimal mode of pumping equipment operation, head and flow.

INTRODUCTION

Pumping systems for natural, drinking, industrial and waste water, reagent and air supply account for more than 90% of the total energy consumption in the water supply systems of industrial facilities. Rapidly rising electricity, gas and oil prices in all countries raise the issue of increasing the energy efficiency of water supply systems as well as their components. This explains the increasing requirements of international and European standards (ISO and EN) with regard to both energy efficiency and the quality of pumping equipment. For example, the international association of European pump manufacturers Europump has introduced a new approved pump marking scheme. The need for this label was based on the fact that there are big differences in energy consumption and a different level of technological development between East and West Europe. Only 20 % of the pump systems installed in the European Union have been optimized for energy consumption [3].

Current practice shows that pumping equipment is extremely inefficient.

Reducing energy consumption, which is one of the main objectives when modernizing water supply facilities or replacing pumping equipment, is primarily achieved by ensuring that the system and pumps operate in an energy-optimized way.

PROBLEM DISCUSSION

The total energy consumption depends to a large extent on the pumping equipment. The efficiency of a pumping station is often lower than the efficiency of the individual pumps installed. The reason for low energy efficiency is the mismatch between the performance of the equipment and the system as a whole, as well as the incorrect operation of the system. To improve plant efficiency, the operating costs of the pumping equipment should be reduced, and the reliability and durability of the equipment should be increased. Thus, it is necessary to modernise the equipment taking into account all the peculiarities of the technological processes in the system [4]. The total energy consumption is to a large extent determined by the pumping

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equipment. The efficiency of a pumping station is often lower than that of the individual pumps installed. The reason for the low energy efficiency lies in the mismatch between the performance of the equipment and the system as a whole as well as in its mismanagement. To improve plant efficiency, the operating costs of the pumping equipment should be reduced, and the reliability and durability of the equipment should be increased. Therefore, a modernisation of the equipment is required, taking into account all the special features of the technological processes in the system [7,8].

MATERIALS AND METHODS.

Selection of an over dimensioned pump: What is the consumer's rationale? Very often the consumer is driven by a desire to cover existing and future requirements with an over dimensioning of the pumping equipment to be purchased. As a rule, water consumption in water supply systems varies considerably depending on the time of day, day of the week and season, as can be seen in figure 1. The plant has to meet both normal and peak demands. Often this is supplemented by the need to supply water for fire-fighting systems. In the absence of regulation, the pump cannot operate efficiently over the entire range of varying water requirements. Other common reasons for over-measuring pumps are design errors, changed water consumption volumes. Consumers are also often inclined to buy a pump with a certain head reserve and a larger motor. If the previous misconception can be explained in terms of rationality, it is due to a misconception of the pump's function. When a pump with a higher head and a larger motor is in use, the motor is overloaded and the consumer wants to replace the pump with one with a higher head and a larger motor, but this does not make any difference and the result remains the same [6]. Figure 1 illustrates this situation.

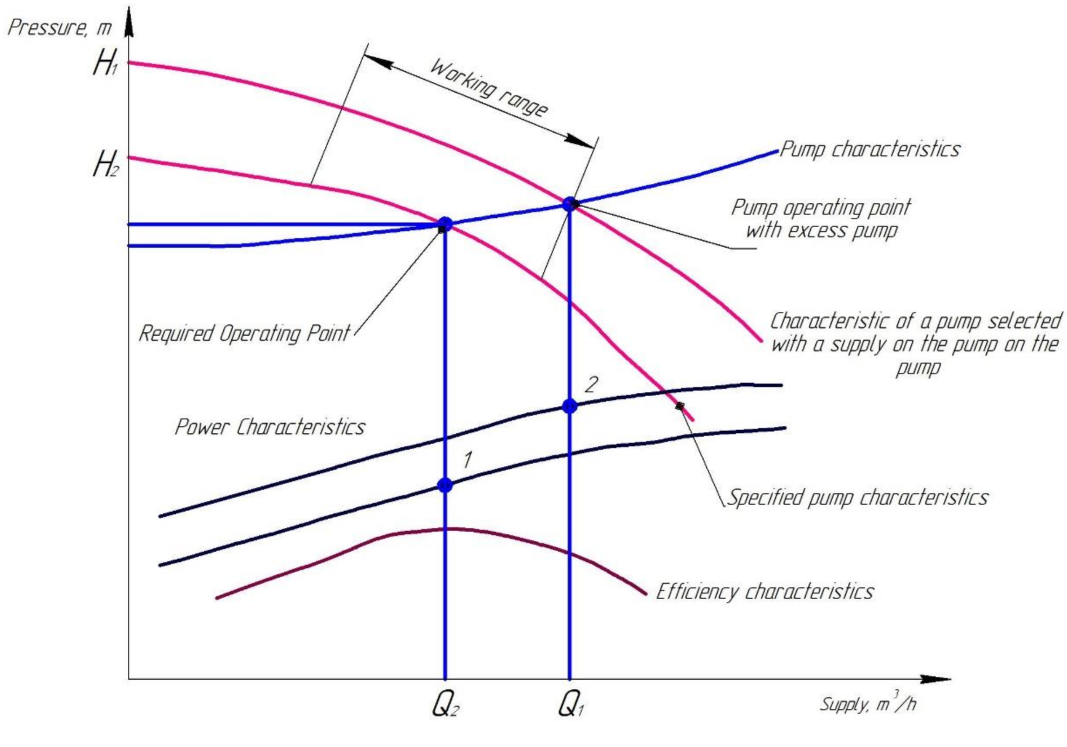

Fig. 1. Selection of a high head pump

At the required flow Q2 and the required head H1, the customer chooses a pump with head H2. As can be seen in the figure, the operating point, defined by the intersection of the pump characteristic and the system characteristic, is shifted to the right of the optimum and is outside the operating range. The pump operation is characterised by higher flow Q1 and higher power consumption, which leads to overloading of the motor (point 2). The pump with the required head is operating at the optimum operating point. The most energy-intensive way of controlling pump operation, unfortunately, is nowadays by means of a throttle valve.

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RESULTS AND DISCUSSION.

The main problem in developing energy saving measures at existing facilities is that the actual network parameters are often not known or are not given in full and differ significantly from the design parameters. The differences are usually related to corrosion of pipelines, changes in water supply schemes, volume of water consumption, etc. In order to determine the actual operating conditions of pumps and network parameters it is necessary to make measurements directly at the site using special measuring equipment, i.e. technical audit of the hydraulic system [5]. To successfully implement measures to improve the energy efficiency of the installed equipment, it is necessary to have as much information about the pumps as possible. There are several successive stages in the pump audit. Step 1: Gathering preliminary information about the equipment installed on site, especially about the process in which it is used. For example, the operating modes of pumps in first and second lift stations are usually quite different from each other. Step 2: Refine the information collected and obtain additional data, check the availability of on-site measuring instruments, analyse the control system, etc. Pre-planning for tests. Step 3: Conduct onsite trials. Step 4. Process and evaluate results. Step 5: Prepare feasibility study for different retrofitting options. When planning measures, the most energy problematic pumps can be identified. Table 1. The table 1 shows the main signs of inefficiencies in pumping equipment and typical measures that can correct these problems, together with an indication of their expected payback period.

Table 1. Causes of high energy consumption and measures to reduce it

Causes of high energy consumption	Recommended measures to reduce energy consumption	Expected payback period of activities
In intermittent systems, pumps that operate continuously regardless of process needs	Determination of the need for continuous pump operation. Switching the pump on and off manually or automatically at defined intervals	From a few days to a few months
Systems with time-varying required flow rates	Use of variable speed drive for systems with prevailing friction losses. The use of pumping stations with two or more pumps installed in parallel for systems with a predominantly static characteristic.	From a few months to a few years
Over-dimensioning of the pump and its operation outside the working area, resulting in high repair costs (replacement of mechanical seals on bearings)	Impeller trim. Impeller replacement. The use of motors with lower speeds or gearboxes in cases where the pump parameters far exceed the system requirements. Replacing the pump with a smaller size	From a few weeks to several years
Wear and tear on the pump's main components	Repair and replacement of pump components in case of deterioration of its performance parameters	a few weeks
Clogged and corroded pipes	Pipeline cleaning. Use of filters, separators and similar fittings to prevent clogging. Renovation with modern plastic pipes, pipes with protective coating	From a few days to a few months
Continuous operation of several pumps installed in parallel	Installation of a new control system or adjustment of an existing one	A few weeks

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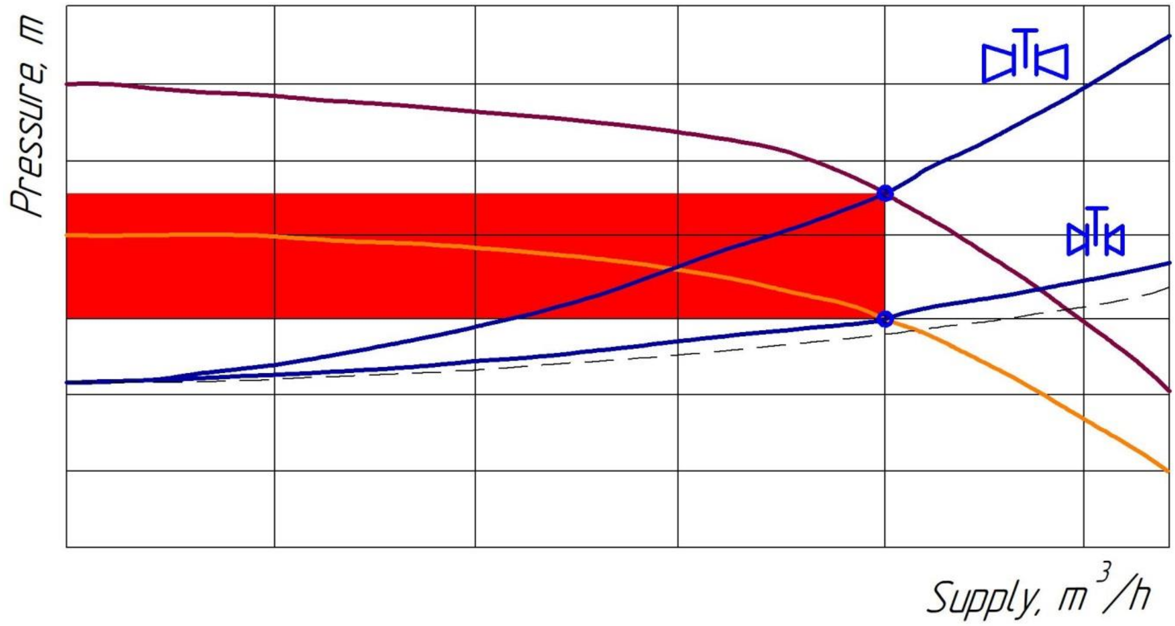

Fig. 2. Reduced power loss when installing a pump with a lower head

CONCLUSION.

The right choice of equipment can save more than 20% energy per year, which is comparable to the cost of the pump itself.

With the results of the tests carried out and the characteristics of the system, knowing its changes over time (hourly, daily, weekly and other schedules), determining the actual performance of the pumps and their operating modes for each characteristic load (longest operating time, maximum/minimum flow), one or more options for pumping equipment upgrading can be developed.

The results of the studies show that the efficiency of centrifugal dewatering plants can be improved by adjusting the operating modes to suit the operating conditions.

Thus, one of the best ways to improve the energy efficiency of a pumping unit may be a method of controlling the operating modes of the unit without changing the power at the drive.

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